DIRECTIONS

177564 *Issue* 2

GE LAICES

Electronic Services - Los Angeles
M10226X

8690-2

MILLIVOLT POTENTIOMETER

LEEDS & NORTHRUP

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- *Measurements from — 11.0 to +101.0 mV*
- *Decade and slidewire operation with in-line readout*
- *Long 27.5" scale provides high resolution for precise readings*
- *Slidewire overlap eliminates decade operation for small voltage changes*
- *Self contained; built-in electronic null detector, standard cell and batteries*
- *Measures below 0 mV without input reversal*
- *Useful for routine checking of thermocouples, recorders and controllers*
- *Manual reference-junction compensator for T.C. measurement*
- *Provides calibrated D.C. source for calibration of meters, potentiometers, recorders, etc.*

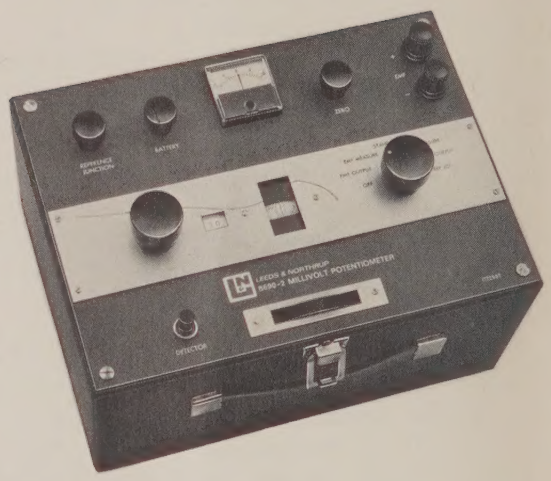


Fig. 1—8690-2 Millivolt Potentiometer.

SPECIFICATIONS

CATALOG NUMBER 8690-2, Portable Millivolt Potentiometer.

RANGE -11.0 millivolts to +101.0 millivolts.

LIMITS OF ERROR* Without ref. jct. compensation: ±(0.05% of reading +15 microvolts); With ref. jct. compensation: ±(0.05% of reading +30 microvolts).

MAX. EXTERNAL RESISTANCE Approx 1000 ohms

MEASURING DIALS Millivolt Dial: 9 x 10 millivolts plus a minus (-) position; Slidewire: 0 to 11 millivolts, two-turn, 27.5 inches long.

SMALLEST SCALE DIV. 20 microvolts.

RESOLUTION 5 microvolts.

REF. JCT. COMPENSATOR Uncalibrated, multi-turn. Range 0 to 5 millivolts. Adjustable to 5 microvolts.

STD. CELL ADJUSTMENT Recessed. Provides adjustment for standard cell voltages from 1.0170 volts to 1.0200 volts.

DETECTOR Solid-state; Sensitivity: 50 μV per division; Noise: < 10 μV peak to peak; Input-Resistance: 10,000 ohms; Common Mode Rejection; > 132 dB; Normal Mode Rejection: > 70 dB; Zero Adjustment Range: ±15 mV; Response Time: < 1 second; Zero Stability: Time, < 10 μV/hr noncumulative; Temp., < 10 μV/degree C; Source Res., < 10 μV for 1000 ohm change. Overload Recovery Time: < one second for 1 V overload. Max. Overload: 2 V.

BATTERY RHEOSTAT Ten-turn. For adjustment of battery current.

FUNCTION SWITCH Seven-position: (1) "OFF"; (2) "EMF OUTPUT"; (3) "EMF MEASURE"; (4) "STANDARDIZE"; (5) "TC MEASURE"; (6) "TC OUTPUT"; (7) "REF JCT".

DETECTOR KEY Lock-down.

BATTERIES Self-contained. One 1.5 V dry cell for measuring circuit; two 4.05 V mercury batteries for detector. Life of batteries is over 1000 hours continuous duty, or over 1 year at 4 hrs./day, 5 days/week.

CASE Metal with handle and removable lid.

DIMENSIONS 12-11/32" x 8-29/32" x 7-9/16" (314 x 226 x 192 mm).

WEIGHT Net, about 13 lb (5.897 kg); shipping, about 17 lb (7.711 kg)

DIRECTIONS Operating directions and Thermocouple Conversion Tables included. Stored in lid.

OPTIONS L&N Report of Calibration (add -B suffix to Catalog Number).

Run-Up Box, mounted in lid of potentiometer (add -R suffix to Catalog Number); Output Ranges: 0 to 60 mV and 60 to 120 mV adjustable to better than +0.02 mV. Output resistance: 0 to 25 ohms adjustable within ±0.5 ohm. Includes two-conductor, color-coded cable with lugs for connections.

OPTIONAL ACCESSORIES

9912 Run-Up Box.

124289 Cable Kit and New Lid for mounting 9912 in potentiometer. (Order 9912 separately).

**Using corrections shown on the L&N Report of Calibration, the limits of error at 25°C are. . .Without Reference Junction Compensation: ±(0.02% +10 μV); With Reference Junction Compensation: ±(0.02% +20 μV).*

PART I—GENERAL INFORMATION

1. GENERAL DESCRIPTION

The 8690-2 Millivolt Potentiometer, illustrated in Fig. 1, is a portable battery operated single-range two-dial potentiometer designed for general temperature measurements, by means of thermocouples, within the range of -11.0 to +101.0 millivolts without reversing its input connections. It can also be used for checking thermocouple pyrometers in laboratory and plant, and as a source of calibrated voltage. In addition, it can be used with a 9912 Run-Up Box to check millivoltmeter type indicators or for the dynamic checking of low range Speedomax® recorders or similar instruments.

Basically, the potentiometer consists of a millivoltage switch, a slidewire, and a function switch. An electronic null detector, a standard cell, and potentiometer and detector circuit batteries are also included in the potentiometer.

The millivoltage value determined by the position of the millivoltage switch appears at the window adjacent to the switch; the millivoltage value determined by the position of the slidewire appears at the center window. The sum of these two readings is the value of the millivoltage measured or supplied by the potentiometer. A range of 0 to -11 millivolts is obtained by turning the millivoltage switch to the minus (-) position. In this instance, all measurements are made by adjusting the slidewire only and the negative values of millivoltage appear at the slidewire scale window.

2. DESCRIPTION OF PRINCIPAL COMPONENTS

The principal components of this potentiometer are identified on Figs. 2, 3, 4, and 5 and are described in the following subsections.

2A. Function Switch

This switch has the following seven positions to provide internal connections when rotated clockwise.

OFF position which disconnects the three batteries from their respective circuits, and the detector and input circuits from the potentiometer circuit.

EMF OUTPUT position which provides a calibrated uncompensated millivoltage at the EMF binding posts.

EMF MEASURE position which permits making of uncompensated millivoltage measurements.

STANDARDIZE position which permits adjustment of the potentiometer circuit current by the battery rheostat in order to standardize the potentiometer circuit.

TC MEASURE position which permits making of compensated millivoltage (thermocouple) measurements.

TC OUTPUT position which provides a calibrated compensated millivoltage at the EMF binding posts.

REF JCT position which permits adjustment of the reference junction compensator.

2B. Millivoltage Switch and Slidewire Scale Setter

The millivoltage switch and slidewire scale setter are used to obtain a potentiometer circuit balance when measuring an unknown millivoltage, or to establish the value of the calibrated millivoltage when the potentiometer is used as a source of millivoltage.

Table I lists the ranges provided by the millivoltage switch and the slidewire as well as other data pertinent to these two components.

Each step (numbered division) of the millivoltage switch is equal to a change of 10 millivolts. Each numbered division of the slidewire scale is equal to a change of 0.1 millivolt. However, the slidewire scale is so divided that the smallest division is equal to a change of 0.02 millivolt.

The setting of the millivoltage switch appears on the millivoltage scale located

TABLE I—RANGES PROVIDED BY MILLIVOLTAGE SWITCH AND SLIDEWIRE				
COMPONENT	POSITIONS	SCALE MARKINGS	RANGE	
			NEGATIVE	POSITIVE
Millivoltage Switch	(11) 0 1 to 10	"-" 00 to 90	- -	- 0 to 90mV
Slidewire	Continuous	0 to 11	0 to -11mV	0 to 11mV
TOTAL RANGE			0 to -11mV	0 to 101mV

to the right of the millivoltage switch, while the setting of the slidewire appears on the slidewire scale (center window of the potentiometer).

2C. Detector Meter

The detector meter indicates the unbalance between the potentiometer circuit emf and the measured emf.

2D. Battery Rheostat

This rheostat adjusts the current provided by the potentiometer circuit battery for standardizing the potentiometer circuit.

2E. Detector Key

This key has two positions:

Up position which opens the detector circuit.

Down position which closes the detector circuit; the key can be locked down in this position by being turned clockwise.

2F. Zero Control

This control adjusts the electrical zero of the detector.

2G. Reference Junction Compensator

This multi-turn slidewire sets the reference junction voltage to the value which corresponds to the temperature of the reference junction when the potentiometer is used to measure thermocouple millivoltages or when it is used to supply similar calibrated millivoltages.

The reference junction is located at the emf binding posts when extension leadwires are used to connect the thermocouple to the potentiometer. However, the reference junction is at the thermocouple head when copper leadwires are used to make the connections.

The reference junction voltage corresponding to the reference junction temperature can be obtained from the appropriate conversion table: 177610 Conversion Tables referenced to IPTS-68 or 077989 Conversion Tables referenced to IPTS-48.

2H. EMF Binding Posts

These binding posts permit the attachment of leads from a thermocouple or other emf source, or from an instrument or device that is to be checked.

2I. Potentiometer-Circuit Battery

This 1.5 volt battery, Fig. 3, provides the current required by the potentiometer circuit.

2J. Detector-Circuit Batteries

These two 4.05 volt batteries, Fig. 4, provide the current required by the detector circuit.

2K. Standard Cell

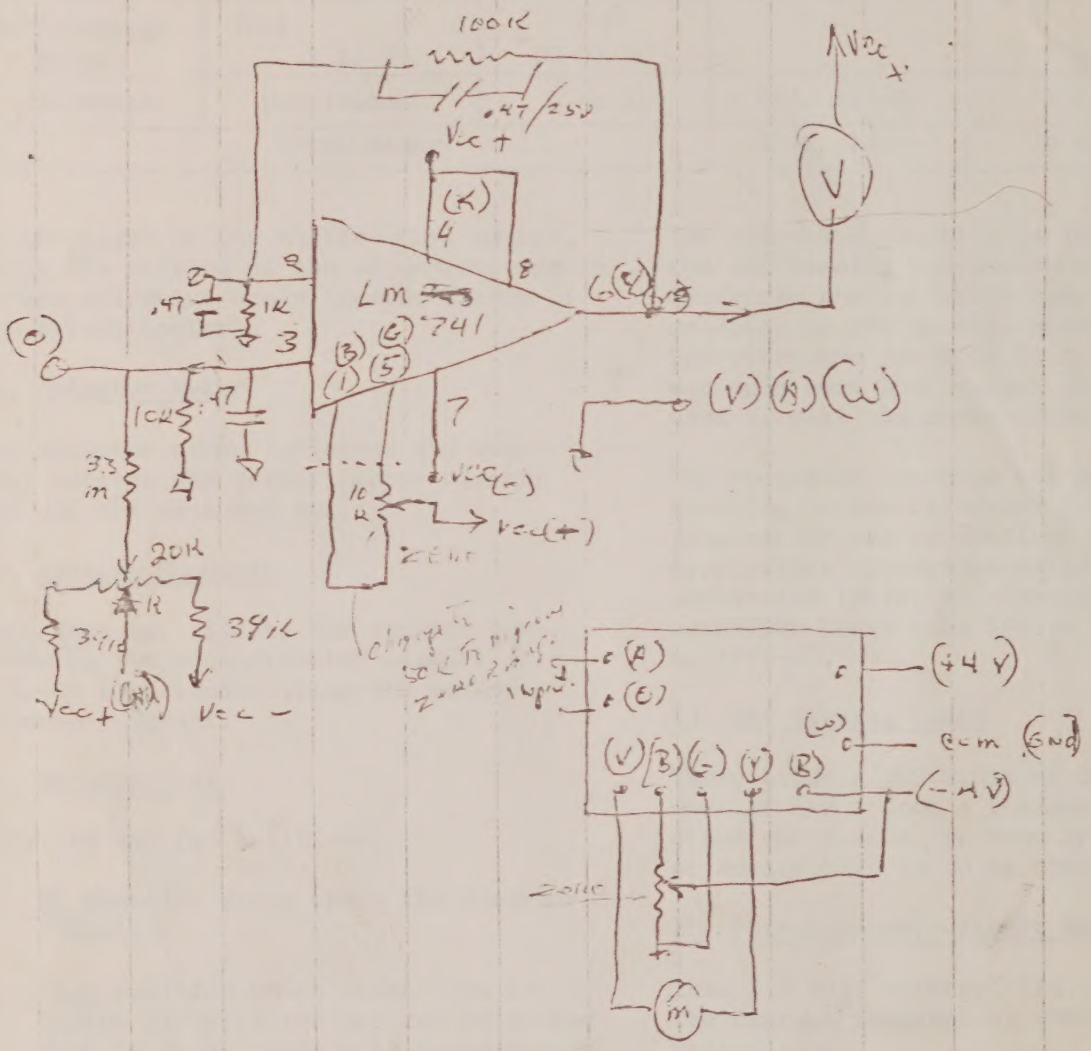
The standard cell, Fig. 5, provides a standardizing voltage of 1.0195 volts absolute (within 0.1%) for standardizing the potentiometer circuit current.

2L. Standard Cell Voltage Divider

The standard cell voltage divider, Fig. 4,

L & N 444514 (520453

Galvo Amp



Eveready # E133N 2 ea.

4,05 V.

AFTER REPLACING IC — IN TESTING IT IS FOUND TO READ OFF ON DIAL INDICATION, POT ON NULL ADJ GALVO SYS MUST BE ADJUSTED

compensates for any slight change in the voltage of the standard cell.

2M. Trimmer Rheostat

The trimmer rheostat, Fig. 4, is a locking type rheostat which is used to calibrate the measuring slidewire. It has been set at the factory and requires no further adjustment.

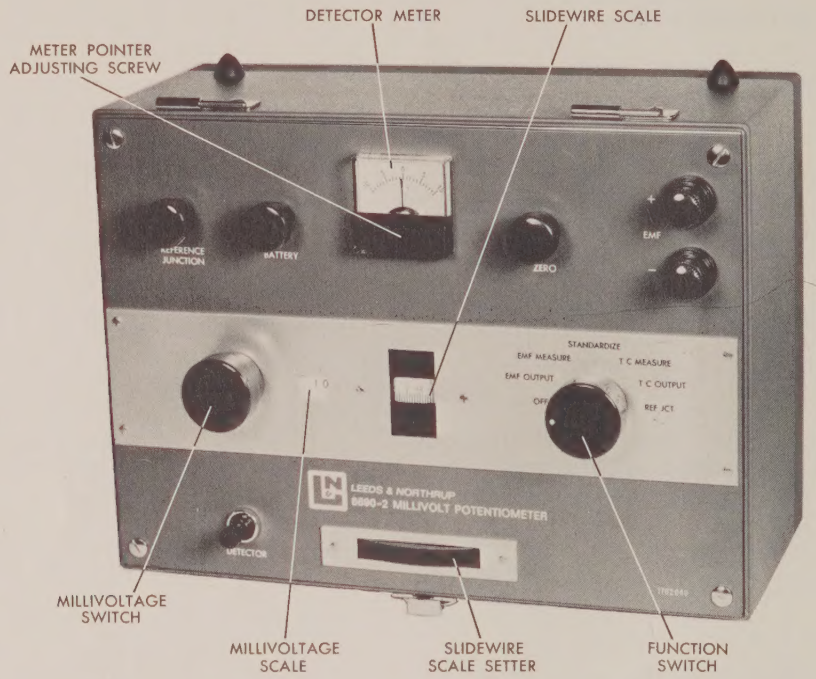
3. OPTIONAL ACCESSORIES

3A. 9912 Run-Up Box

The 9912 Run-Up Box can supply the current flow needed for checking deflection-type millivoltmeters or similar instruments. It can also be used as a low-resistance millivoltage calibration source for dynamic checks of null-balancing galvanometer-type instruments.

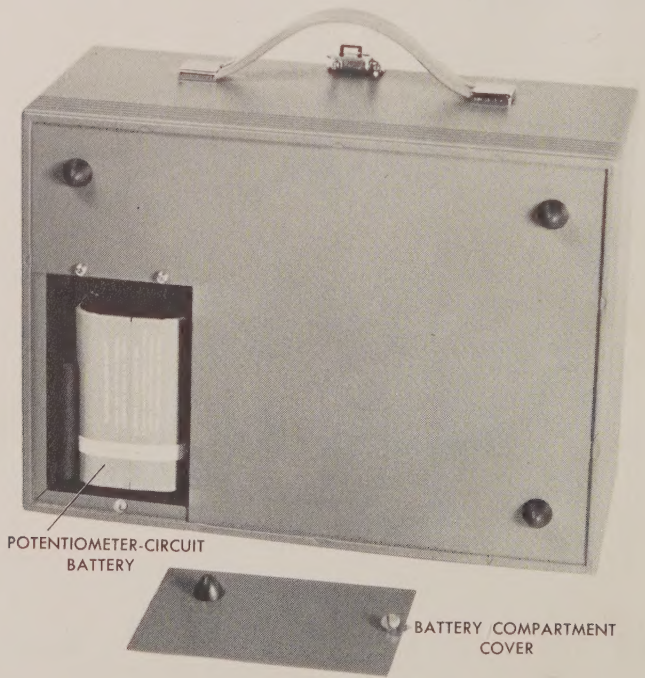
3B. 124289 Lid and Cable Kit

The 124289 Lid and Cable Kit contains parts for mounting a 9912 Run-Up Box on an 8690-2 Millivolt Potentiometer.



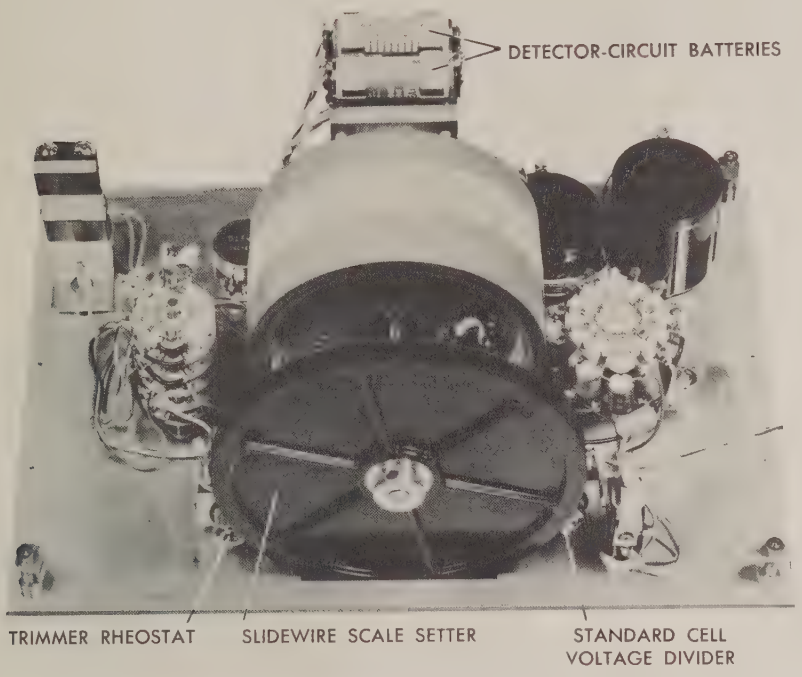
E5698

Fig. 2—Control panel of 8690-2 Millivolt Potentiometer



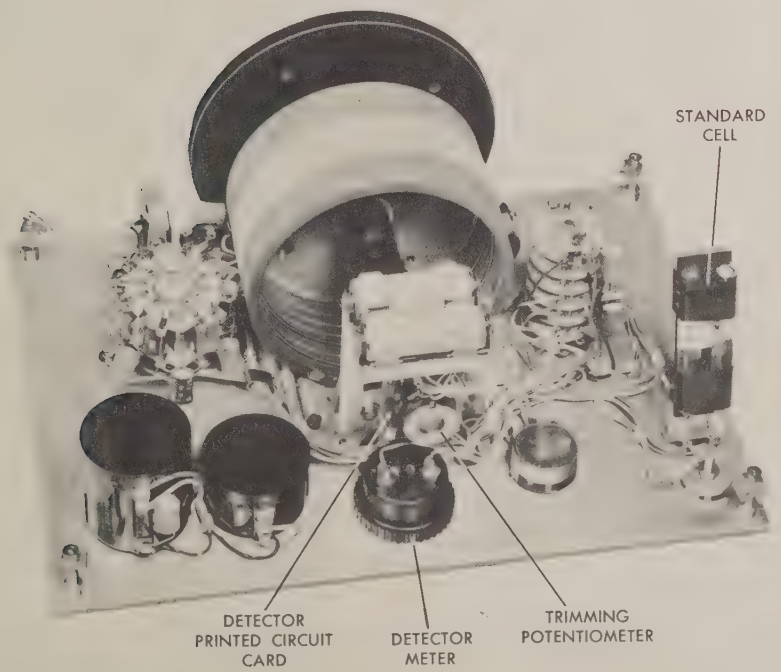
E5674

Fig. 3—Bottom view of 8690-2 Millivolt Potentiometer.



E5699

Fig. 4—Underside of control panel (viewed from slidewire scale setter side).



E5700

Fig. 5—Underside of control panel (viewed from detector meter side).

PART II—TECHNICAL INFORMATION

As shown schematically in Fig. 6, the 8690-2 Millivolt Potentiometer basically consists of a double-branch potentiometer circuit. This circuit is balanced manually by the rotation of the millivoltage switch and/or the slidewire scale setter. The setter extends through the control panel and is coupled mechanically to the drum on which the measuring slidewire and scale are mounted.

4. STANDARDIZATION

The potentiometer circuit is arranged with two branches of equal resistance to which current is supplied by battery BA1. The magnitude of the current is controlled by battery rheostat S1 which is in series with the battery and resistor R1. The circuit is designed to provide a battery drain of 4mA, with the current dividing equally between the two branches. When the current through each branch is adjusted to 2mA, the potentiometer circuit is standardized.

Standardization is effected by placing the function switch in the standardize position and then depressing the detector key. This connects the detector circuit (printed circuit card, meter M1, zero adjuster S5, and batteries BA2 and BA3) into a loop which includes resistors R17 and R19, reference junction compensator S3, and standard cell voltage divider S4. The standard cell emf is always equal to 1.0195 volts absolute (within 0.1%). The remaining components of this loop are selected so that their resistance is equal to 509.75 ohms. Thus, with 2mA flowing through the loop, the drop across R17, R19, S3, and S4 is equal to 0.002 ampere times 509.75 ohms or 1.0195 volts.

If the current flowing through the preceding loop is equal to 2 mA, the two opposing voltages of the loop balance each other and no current flows in the loop. If the current is not exactly 2mA, the resultant voltage unbalance causes the detector to deflect from its zero (null balance) position. This unbalance is corrected by adjusting battery rheostat S1 until the detector balances. This indicates that 2mA is flowing through the loop and that the two opposing voltages are balanced. Thus standardization is accomplished by the null balance method.

Since battery BA1 is connected in the potentiometer circuit at all times except when the function switch is in the off position, there is considerable current drain from it. Thus the battery emf will decrease gradually. This decrease is corrected by standardizing the circuit before each series of measurements or checks and also by standardizing the circuit at regular intervals, depending upon the stability of the battery.

As the battery emf decreases, repeated standardizations cause more and more of the battery-rheostat resistance to be adjusted out of the circuit. When all the resistance has been adjusted out (that is, when the battery rheostat is at the end of its travel), the current in the circuit can no longer be standardized unless the battery is replaced with a fresh one.

5. MEASUREMENT

When the potentiometer is used to measure millivoltage, the function switch is placed in the appropriate measure position and the detector key is depressed. This connects the thermocouple or emf source to the potentiometer circuit through the detector circuit. The unknown millivoltage is then determined by rotating the millivoltage switch and/or the slidewire scale setter in the proper direction until the detector is balanced. Thus the emf being measured is balanced by the potential difference existing between the measuring slidewire contact and the contact of S3 or the junction of R17 and S3. The millivoltage is indicated by the settings of the millivoltage and slidewire scales.

The millivoltage switch has a total range

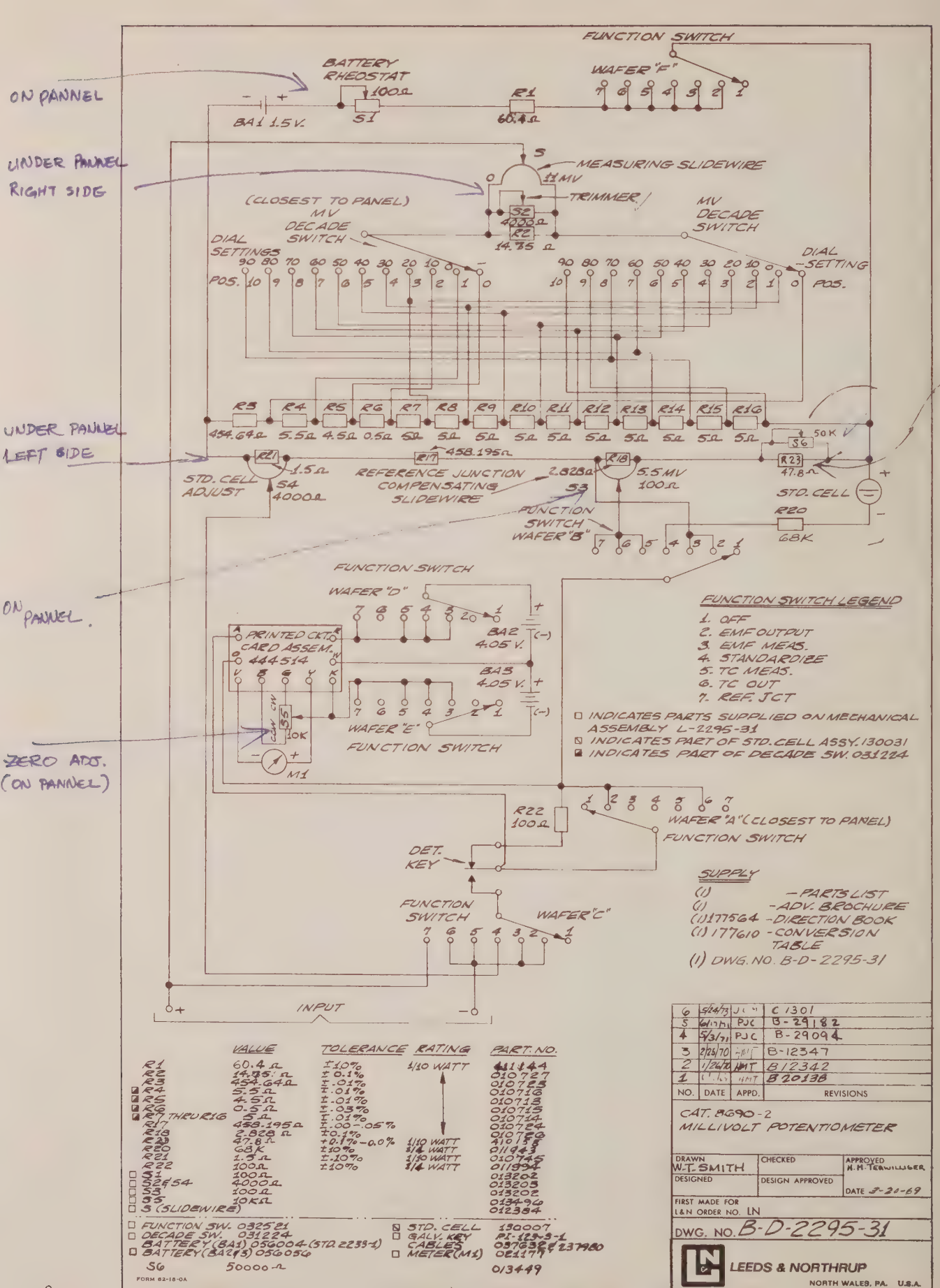
of 0 to 90 millivolts in 10-millivolt steps. The measuring slidewire has a range of 0 to 11 millivolts and is coupled to the millivoltage switch by a Kelvin-Varley arrangement. With the millivoltage switch in the minus position, the polarity of the measuring slidewire is reversed. Therefore, the total millivoltage range of this instrument is -11 to 0 to +101 millivolts.

Measuring slidewire S, trimmer rheostat S2, resistors R2 through R20, reference junction compensator S3, and standard cell voltage divider S4 have been selected to make the potential difference between the measuring slidewire contact and the contact of S3 or the junction of R17 and S3 vary through the measuring range. These components have also been selected to make the total resistance of the upper branch equal to that of the lower branch.

Reference junction compensator S3 is connected in the potentiometer circuit so that its emf can be set to the emf corresponding to the temperature at the reference junction. Standard cell voltage divider S4 is connected in the potentiometer circuit so that its emf can be set to a value that compensates for any change in the voltage of the standard cell.

6. CHECKING

When the potentiometer is used for checking purposes, the function switch is placed in the appropriate output position (thereby shorting out the detector circuit), the millivoltage switch and/or the slidewire scale setter are rotated until the desired millivoltage is indicated by the settings of their respective scales, and the detector key is depressed or locked down. Thus the potential difference existing between the measuring slidewire contact and the contact of S3 or the junction of R17 and S3 is applied to the instrument being checked. The reading on this instrument should then be identical or equivalent to the settings of the millivoltage switch and the slidewire scale of the 8690-2 Millivolt Potentiometer within the combined adjustment accuracy of both instruments. When providing a thermocouple output, reference junction compensator S3 is adjusted so that its emf corresponds to the temperature at the reference junction of the thermocouple being simulated.



FUNCTION SWITCH LEGEND

1. OFF
2. EMF OUTPUT
3. EMF MEAS.
4. STANDARDIZE
5. TC MEAS.
6. TC OUT
7. REF. JCT

□ INDICATES PARTS SUPPLIED ON MECHANICAL ASSEMBLY L-2295-31
▨ INDICATES PART OF STD. CELL ASSY. 130031
■ INDICATES PART OF DECADE SW. 031224

SUPPLY

(1) — PARTS LIST
(1) -ADV. BROCHURE
(1) 177564 -DIRECTION BOOK
(1) 177610 -CONVERSION TABLE
(1) DWG. NO. B-D-2295-31

	VALUE	TOLERANCE	RATING	PART. NO.
R1	60.4 Ω	±10%	1/10 WATT	441144
R2	14.35 Ω	±0.1%		010727
R3	454.64Ω	±.01%		010725
■ R4	5.5Ω	±.01%		010718
R5	4.5Ω	±.01%		010713
■ R6	0.5Ω	±.03%		010715
■ R7 THRU R16	5Ω	±.01%		010714
R17	458.195Ω	±.005-.05%		010724
R18	2.828 Ω	±0.1%		010726
R23	47.8Ω	+0.1%-0.0%	1/10 WATT	410138
R20	68K	±10%	1/4 WATT	011943
R21	1.5Ω	±.10%	1/10 WATT	010745
R22	100Ω	±10%	1/4 WATT	011994
S1	100Ω			013202
S2/S4	4000Ω			013203
S3	100Ω			013202
S5	10KΩ			013196
3 (SLIDEWIRE)				012384

□ FUNCTION SW.	032521	▨ STD. CELL	130007
□ DECADE SW.	031224	□ GALV. KEY	PI-129-3-1
BATTERY (BA1)	050004-(STD 223341)	□ CABLES	037632 & 237980
□ BATTERY (BA2&3)	050054	□ METER (M1)	021177
S6	50000-Ω		013449

FORM 62-18-0A

NO.	DATE	APPD.	REVISIONS
6	5/24/73	JLC	C 1301
5	6/17/71	PJC	B-29182
4	5/31/71	PJC	B-29094
3	2/25/70	HMT	B-12347
2	1/26/70	HMT	B12342
1	[illegible]	HMT	B 20138

CAT. 8690-2
MILLIVOLT POTENTIOMETER

DRAWN	CHECKED	APPROVED
W.T. SMITH		H.M. TERWILLIGER
DESIGNED	DESIGN APPROVED	DATE 3-21-69

FIRST MADE FOR L&N ORDER NO. LN

DWG. NO. B-D-2295-31

LEEDS & NORTHRUP
NORTH WALES, PA. U.S.A.

MISCELLANEOUS PARTS

SYMBOL	DESCRIPTION	L&N PART NO.
BA1	Potentiometer-Circuit Battery, 1.5 V	056004
☐BA2	Detector-Circuit Battery, 4.05 V	056056
☐BA3	Detector-Circuit Battery, 4.05 V	056056
☐M1	Detector Meter	021177
R1	Resistor, ±10%, 1/10 W, 60.4Ω	411144
R2	Resistor, ±0.1%, 1/10 W, 14.75Ω	010727
R3	Resistor, ±0.01%, 1/10 W, 454.64Ω	010723
◪R4	Resistor, ±0.01%, 1/10 W, 5.5Ω	010716
◪R5	Resistor, ±0.01%, 1/10 W, 4.5Ω	010713
◪R6	Resistor, ±0.03%, 1/10 W, 0.5Ω	010715
◪R7 Thru R16	Resistor, ±0.01%, 1/10 W, 5Ω	010714
R17	Resistor, ±0.00 — 0.05%, 1/10 W, 458.195Ω	010724
R18	Resistor, ±0.1%, 1/10 W, 2.828Ω	010726
R23	Resistor, -0.06% — 0.08%, 1/10 W, 47.8Ω	410158
R20	Resistor, ±10%, 1/4 W, 68 KΩ	011943
R21	Resistor, ±10%, 1/10 W, 1.5Ω	010745
R22	Resistor, ±10%, 1/4 W, 100Ω	011994
☐S	Slidewire	012384
☐S1	Battery Rheostat, 100Ω	013202
☐S2	Trimmer Rheostat, 4000Ω	013203
☐S3	Reference Junction Compensator, 100Ω	013202
☐S4	Standard Cell Voltage Divider, 4000Ω	013203
☐S5	Zero Control, 10 KΩ	013496
--	Cable (Potentiometer-Circuit)	037632
--	Cable (Detector-Circuit)	237980
☐--	Detector Key	031014
☐--	Function Switch	032521
☐--	Millivoltage Switch	031224
◪--	Standard Cell	130031
S6	50 KΩ Trimmer	013449

NOTE: This is the latest version of the schematic diagram at the time of printing. If differences are noted between the instrument and this diagram, refer to the diagram supplied with the instrument.

Fig. 6—Schematic diagram with Miscellaneous Parts List of 8690-2 Millivolt Potentiometer.

PART III—OPERATING INSTRUCTIONS

7. PRECAUTIONS

The potentiometer contains an unsaturated standard cell which should not be subjected to temperatures below 32° F (0° C) or above 122° F (50° C). Therefore, operate this potentiometer only at locations where the ambient temperature remains within the preceding temperature limits.

After standardizing the potentiometer circuit with the DETECTOR key locked down, do not leave the function switch in the STANDARDIZE position for an extended period, as this may damage the standard cell.

To prolong the life of batteries, keep the function switch in the OFF position when the potentiometer is not being used.

Before storing the potentiometer or keeping it inoperative for months, remove the batteries to avoid possible damage from leakage.

8. PRELIMINARY ADJUSTMENTS

8A. Adjust Mechanical Zero of Detector

Place the function switch in the OFF position. Then adjust the meter pointer adjusting screw, Fig. 2, until the detector pointer balances at zero.

8B. Adjust Electrical Zero of Detector

Place the function switch in the STANDARDIZE position. Then check that the DETECTOR key is in the up position. Adjust the ZERO control until the detector pointer balances at zero.

8C. Check Detector Current Offset

Periodically, check the detector current offset by proceeding as follows:

Adjust the electrical zero of the detector as directed in Section 8B.

Turn the function switch to the EMF MEASURE or TC MEASURE position.

Open circuit the potentiometer EMF binding posts.

Depress the DETECTOR key.

The detector pointer should now balance at zero ±2 divisions. If it does not, adjust the trimming potentiometer, Fig. 5, on the detector printed circuit card until it does. This card is located on the bracket mounted behind the detector meter. Access to the card can be gained by removing the control panel from the potentiometer case as instructed in Section 16A.

8D. Standardize Potentiometer Circuit

Standardize the potentiometer circuit before each initial measurement or check. Also standardize at regular intervals, depending upon the stability of the potentiometer-circuit battery.

To standardize the potentiometer circuit-that is, to adjust the current in this circuit-proceed as follows:

(1) Place the function switch in the STANDARDIZE position.

(2) Check the electrical zero of the detector and, if necessary, adjust it as directed in Section 8B.

(3) Depress or lock down the DETECTOR key. If the detector pointer deflects from its zero (null balance) position, adjust the BATTERY rheostat until the pointer balances at zero.

(4) After standardizing the potentiometer circuit, place the function switch in the OFF, EMF OUTPUT, or TC OUTPUT position and unlock the DETECTOR key.

9. MAKE MILLIVOLTAGE CONNECTIONS

If a millivoltage source other than a thermocouple is to be measured, connect

the source to the binding posts of the potentiometer with copper wire; if the source is a thermocouple, connect it to the EMF binding posts as directed in Section 11.

If the potentiometer is to be used as a source of calibrated millivoltage, connect the device to which this millivoltage is to be applied to the EMF binding posts.

In both instances, be sure that the polarites of the connections are correct.

10. ADJUST REFERENCE JUNCTION COMPENSATOR

Adjust the reference junction compensator only when measuring the millivoltage of thermocouples whose reference junction temperature is other than 32° F (0° C), or when using the potentiometer to supply similar calibrated millivoltages in applications where the reference junction temperature is other than 32° F.

If, for either of the preceding two applications, the reference junction temperature is exactly 32° F, as it would be if the reference junctions were located in an ice bath or in an automatic thermocouple reference system, such as an 8435 Automatic Thermocouple Reference System, switch the reference junction compensator out of the potentiometer circuit to obtain maximum accuracy. Bring this about by placing the function switch in either the EMF OUTPUT or EMF MEASURE position.

To adjust the reference junction compensator, proceed as follows:

(1) Determine the temperature at the reference junction with a mercury thermometer or an equivalent device. Since any final temperature measurement involving a thermocouple and potentiometer is basically a difference between the measured temperature and the temperature of the reference junction, the reference junction temperature must be determined to an accuracy in keeping with the desired accuracy of the final temperature measurement.

(2) Refer to the applicable conversion tables for the type thermocouple being used and obtain the millivoltage value corresponding to the reference junction temperature.

(3) Set the millivoltage switch at 00 and turn the slidewire scale setter so that the reading on the slidewire scale equals the millivoltage value corresponding to the reference junction temperature.

For example, assume that the thermocouple being used is a Type J-68 thermocouple and that the reference junction temperature is 80° F. Then the millivoltage corresponding to this temperature as determined from the 177610 Conversion Tables for Thermocouples is 1.363 millivolts. Consequently, the millivoltage switch should be set at 00 and the slidewire scale setter turned until the slidewire scale indicated 1.363.

(4) Place the function switch in the REF JCT position.

(5) Depress the DETECTOR key and adjust the reference junction compensator until the detector balances at zero.

(6) Then turn the function switch to either the TC MEASURE or TC OUTPUT position, as required.

11. STABILIZE REFERENCE JUNCTION TEMPERATURE

To measure temperature with a thermocouple and the 8690-2 Millivolt Potentiometer, the temperature of the reference junction must be known and kept reasonably constant. Under normal conditions, the reference junction temperature is the ambient temperature at the junction of the thermocouple wire and the copper wire leading to the potentiometer or the ambient temperature at the binding posts of the potentiometer. This temperature is relatively constant. Consequently, its short-term fluctuations can be ignored. However, where the effects of these fluctuations

become significant, such as in air-conditioned rooms or in applications where accuracy of the highest degree is required, one of the following methods can be used to maintain a relatively constant reference junction temperature which is independent of ambient temperature fluctuations.

11A. Ice Bath Method

In this method, which uses the connections shown in Fig. 7, two ice baths maintain the reference junction temperature at 32° F (0° C). Note that the reference junctions are at the junctions of the copper and thermocouple extension wires instead of at the EMF binding posts. Since the conversion tables for thermocouples are based upon a reference junction temperature of 32° F, the reference junction compensator should be eliminated from the potentiometer circuit and, consequently, the function switch should be placed in either the EMF OUTPUT or EMF MEASURE position.

Each ice bath consists of a thermally insulated container (having an inside diameter of 1-1/2 to 2-1/2 inches) in which a mixture of compacted distilled crushed ice and distilled water surrounds the reference junction. The quantity of distilled water used should be limited to the quantity necessary to fill the air spaces between the pieces of ice.

Make sure that the junctions are immersed at least four inches in the ice baths and that they are at least one inch away from the bottoms of the containers. Also make sure that the crushed ice is pressed firmly around the reference junction wires.

A single ice bath can be used if the distilled water is of sufficient purity to insure electrical insulation between the reference junctions of if the junction wires are coated with paraffin to provide the required insulation.

11B. Thermal Insulation Method

A less precise but satisfactory method for maintaining a stable reference junction temperature is to embed the reference junctions in a mass of thermal insulating material, such as a foamed polystyrene. The reference temperature is determined by a mercury thermometer embedded with the reference junctions. In this method, the reference junction temperature is relatively constant in spite of room temperature fluctuations. However, the difference between the reference junction temperature

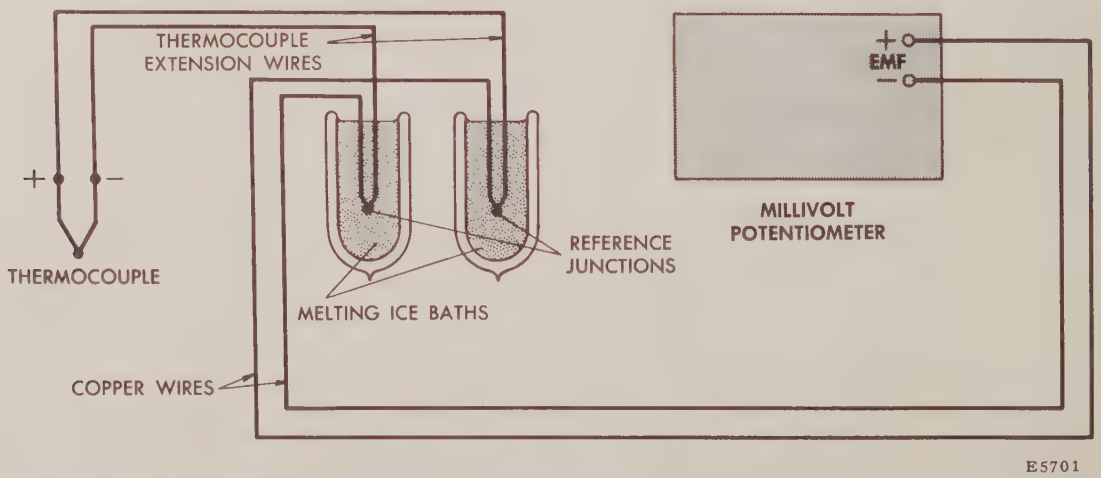


Fig. 7—Connections for measuring output thermocouple using ice bath method.

and 32° F (0° C) must be compensated for by the reference junction compensator.

12. MEASURE MILLIVOLTAGE

12A. Procedure

Make sure that all the preliminary adjustments and checks outlined in Section 8 have been executed. Also make sure that the connections as indicated in Section 9 have been made. Then proceed in accordance with the pertinent instructions indicated in the following table.

MILLIVOLTAGE MEASUREMENT		PLACE FUNCTION SWITCH IN POSITION	ADJUST REFERENCE JUNCTION COMPENSATOR*	COMPLETE MEASUREMENT IN ACCORDANCE WITH
TYPE	RANGE			
Uncompensated	0 to 101mV	EMF MEASURE	No	Section 12B
Uncompensated	-11 to 0mV	EMF MEASURE	No	Section 12C
TC Compensated	0 to 101mV	TC MEASURE	Yes	Section 12B
TC Compensated	-11 to 0mV	TC MEASURE	Yes	Section 12C

**As indicated in Section 10.*

12B. Final Steps of Procedure for 0 to 101mV Range

Turn the millivoltage switch to 00 and the slidewire scale setter until the slidewire scale indicates 0.

Depress the DETECTOR key and note the deflection of the detector pointer.

Turn the millivoltage switch clockwise, one position at a time, depressing the DETECTOR key momentarily for each position, until the deflection of the detector pointer reverses.

Turn the millivoltage switch back one position.

While keeping the DETECTOR key depressed, turn the slidewire scale setter slowly to the left until the detector pointer balances at zero.

Read the values indicated on the millivoltage and slidewire scales. The sum of these readings is the value of the millivoltage being measured. For example: if the millivoltage scale indicates 20 and the slidewire scale indicates 10.54, then the reading is equal to 30.54 millivolts.

12C. Final Steps of Procedure for -11 to 0mV Range

Turn the millivoltage switch to the "-" position and the slidewire scale setter until the slidewire scale indicates 0.

Turn the slidewire scale setter slowly to the left while keeping the DETECTOR key depressed until the detector pointer balances at zero.

Read the value indicated on the slidewire scale; it is the value of the negative millivoltage being measured. For example; if the slidewire scale indicates 9.42, then the reading is equal to -9.42 millivolts.

13. SUPPLY MILLIVOLTAGE

13A. Procedure

To use the 8690-2 Millivolt Potentiometer as a source of calibrated millivoltage, proceed as follows:

> CAUTION: *Although the 8690-2 Millivolt Potentiometer can be used as a source of millivoltage, it is not designed for use as a source of current. Therefore, use the potentiometer in null balance circuits only. Note that the internal resistance of the potentiometer at the EMF binding posts varies between 50 and 135 ohms, depending upon the setting of the potentiometer.*

Make sure that the preliminary adjustments and checks outlined in Section 8 have been executed.

Depress the DETECTOR key and lock it in the depressed position by turning it clockwise. Then complete the procedure by proceeding in accordance with the pertinent instructions indicated in the following table.

MILLIVOLTAGE SUPPLIED		PLACE FUNCTION SWITCH IN POSITION	ADJUST REFERENCE JUNCTION COMPENSATOR*	COMPLETE PROCEDURE IN ACCORDANCE WITH
TYPE	RANGE			
Uncompensated	0 to 101mV	EMF OUTPUT	No	Section 13B
Uncompensated	-11 to 0mV	EMF OUTPUT	No	Section 13C
TC Compensated	0 to 101mV	TC OUTPUT	Yes	Section 13B
TC Compensated	-11 to 0mV	TC OUTPUT	Yes	Section 13C

**As indicated in Section 10.*

13B. Final Steps of Procedure for Supplying Millivoltage of 0 to 101mV

Rotate the millivoltage switch and the slidewire scale setter until the sum of the values indicated by the corresponding scales equals the desired millivoltage that is to be supplied by the potentiometer. For example; if the millivoltage scale is set at 40 and the slidewire scale to 5.92, then the millivoltage supplied by the potentiometer equals 45.92 millivolts.

13C. Final Steps of Procedure for Supplying Millivoltage of -11 to 0mV

Turn the millivoltage switch to the "-" position and the slidewire scale setter until the slidewire scale indicates the millivoltage that is to be supplied by the potentiometer. For example; if the slidewire scale indicates 8.68, then -8.68 millivolts is being supplied by the potentiometer.

PART IV—MAINTENANCE

The 8690-2 Millivolt Potentiometer is designed for reliable trouble-free operation. With reasonable care in handling and use, no normal maintenance is required other than periodic replacement of the batteries. Instructions for battery replacement and other less frequent maintenance procedures are given in the following sections.

14. BATTERIES

14A. Potentiometer-Circuit Battery

When it is no longer possible to standardize the potentiometer circuit because the battery rheostat has reached the limit of its adjustment, replace the present potentiometer-circuit battery, Fig. 3, with a new one. This battery is located in a compartment inside the potentiometer case. To gain access to the battery compartment, it will be necessary to remove its cover which is fastened to the bottom of the case with a thumbscrew.

CAUTION: *Replace the potentiometer-circuit battery at least once every twelve months, regardless of usage, to minimize the possibility of leakage and the resulting damage to the potentiometer.*

14B. Detector-Circuit Batteries

When it is no longer possible to balance the detector pointer at zero or if a decrease in the detector sensitivity is noted, replace the two 4.05-volt detector-circuit batteries, Fig. 4. These batteries are mounted on the bracket located behind the detector.

To replace these batteries, proceed as follows:

Place the function switch in the OFF position.

Remove the control panel from the case as directed in Section 16A to expose the batteries.

Pry the batteries out of their holders with a screwdriver.

Press the new batteries in place, observing proper polarity.

CAUTION: *Replace the detector-circuit batteries at least once every eight to ten months, regardless of usage, to minimize the possibility of leakage.*

15. CONTROL PANEL

The top of the control panel may be cleaned with a soft cloth dampened with water containing a small amount of mild detergent. The scale windows may be cleaned in the same manner.

The insulators of the EMF binding posts are made from a plastic which is affected adversely by some chemical solvents. Therefore, never use such solvents to clean the top of the control panel.

16. MEASURING SLIDEWIRE

16A. Cleaning

The slidewire may require occasional cleaning over extended periods of time, depending upon the conditions under which the potentiometer is used.

Remove the control panel from the case by first turning each control panel mounting screw two complete turns counterclockwise to release the clamping nuts from the ledge inside the case; note that the mounting screws remain in place in the control panel. Then lift the panel out of the case and set it upside down on a suitable surface, such as a work bench or table. Take care not to scratch or damage the surfaces of the knobs, the binding posts, or the detector meter.

Clean and lubricate the slidewire winding only with an approved cleaner which can be obtained from the Leeds & Northrup Company as L&N Part No. 124179. DO NOT clean the winding with any other

lubricant or with an abrasive material.

To replace the control panel, first turn the clamping nut on each of the four panel mounting screws, so that it will clear the ledge inside the case when the panel is remounted on the case. Next turn each panel mounting screw counter-clockwise until a click is heard, and then clockwise until it is tight.

16B. Contact Assembly Replacement

At yearly intervals, or more frequently if the potentiometer is subjected to continuous use, inspect the measuring slidewire contact for wear. Replace the slidewire contact assembly before the soft metal of the contact wears through.

When the contact assembly has been replaced, adjust the contact force as instructed in Section 16C and recalibrate the instrument as described in Section 20.

16C. Contact Force Adjustments

CAUTION: *In making the following checks and adjustments, do not allow the contact to snap down on the slidewire, as this may nick the slidewire and adversely affect calibration.*

The contact should bear against the slidewire with a force of two to three ounces. If the contact force is too low, unreliable electrical connection may result. Excessive force will cause rapid wear of the contact.

When a contact has been disturbed or a new contact assembly has been installed, measure the contact force. To do this, first rotate the slidewire drum to its high-end stop. This stop is mounted on that side of the drum that faces the slidewire scale setter. Then use a spring scale with an L-shaped hook on its end to make the measurement.

If the radial force required to just lift the contact off the slidewire is not within two to three ounces (56 to 84 grams), readjust the contact force.

Excessive contact force can be relieved by bending the contact outward without removing the contact assembly from its mounting on the slidewire assembly. To increase the force, remove the contact assembly, bend the contact as required, and then remount the contact assembly.

After readjusting the contact force, recalibrate the potentiometer as instructed in Section 20.

17. STANDARD CELL

17A. Adjust Voltage Output of Standard Cell Circuit

The limit of error (accuracy) of the potentiometer depends upon the output voltage of the standard cell, Fig. 5, thus a change in the voltage of the standard cell will affect the accuracy of the potentiometer. Therefore, it is recommended that the voltage of the standard cell be checked about once a year and that the voltage output of the standard cell circuit be adjusted accordingly.

To make the preceding check and adjustment, proceed as follows:

(1) Apply 100 millivolts ±0.02% to the EMF binding posts of the potentiometer. Obtain this voltage from a precision potentiometer, such as a 7554 Type K-4 Potentiometer or equivalent.

(2) Adjust the millivoltage switch and the slidewire scale setter until the corresponding scales indicate the millivoltage applied to the potentiometer in Step 1.

(3) Rotate the function switch to the EMF MEASURE position.

(4) Adjust the BATTERY rheostat,

depressing the DETECTOR key at intervals, until the detector balances at zero.

(5) Turn the function switch to one of the STANDARDIZE positions.

(6) Lock down the DETECTOR key by turning it clockwise. If the detector balances at zero, no adjustment of the standard cell voltage divider, Fig. 4, is necessary.

(7) If the detector does not balance at zero, remove the control panel from the case as directed in Section 16A to provide access to the standard cell voltage divider, Fig. 5. Stand the control panel vertically on its lower edge. Loosen the locknut on the slotted end of the divider shaft. Insert a screwdriver into the slot adjust the divider until the detector balances at zero. Then tighten the locknut.

(8) Release the DETECTOR key and replace the control panel in the case to complete the check and adjustment.

17B. Replace Standard Cell

The standard cell, Fig. 5, may be expected to maintain correct emf for several years unless it is accidentally short-circuited. If its open-circuit voltage is less than 1.0175 volts, the cell is unserviceable and must be replaced. Measure the open-circuit voltage of the cell with a precision potentiometer, such as a 7554 Type K-4 Potentiometer or equivalent. Make sure that the cell is disconnected and is in its normal operating position when making the measurement.

To remove the standard cell for test or replacement, proceed as follows:

Carefully remove the control panel as directed in Section 16A to expose the standard cell. Then set it upside down on a suitable surface.

Unsolder the red and blue leads of the cell from the bracket on which the cell is mounted.

To remount the cell or to mount a new one, reverse the above procedure. Make sure that the mounting of the cell conforms to the original mounting arrangement.

Whenever the standard cell has been replaced, recalibrate the potentiometer as instructed in Section 20.

18. DETECTOR PRINTED CIRCUIT CARD

To replace the detector printed circuit card, Fig. 5, proceed as follows:

Place the function switch in the OFF position.

Remove the control panel from the case as directed in Section 16A to expose the card.

Slip off all leads from their respective pins on the card.

Carefully pry the card from its four mounting insulators.

Press the new printed circuit card in place on the mounting insulators. Then reconnect the previously disconnected leads to the pins of the new card. Note that each pin on the card is identified by the color of the lead that should be connected to it.

19. SCALE WINDOW

Should it become necessary to replace the scale window, first remove the knobs from the millivoltage and function switches. Then remove the metal plate to which the window is attached. Replace the window with a new one. Then remount the metal plate and the knobs.

20. CALIBRATION

This section outlines the procedure for checking the calibration of an 8690-2 Millivolt Potentiometer. Such a check is necessasry whenever the slidewire contact assembly has been disturbed or the standard cell has been replaced. The user may also wish to check the calibration periodically.

To check calibration, make all adjustments and settings and take all readings as accurately as possible. Proceed as follows:

(1) Standardize the potentiometer circuit. Then place the function switch in the EMF MEASURE position and unlock the DETECTOR key.

(2) Carefully remove the control panel from the case as directed in Section 16A to expose the underside of the panel. DO NOT disconnect any wiring.

(3) Connect a source of calibrated voltage, such as a 7554 Type K-4 Potentiometer or equivalent, to the EMF binding posts with copper wire.

(4) Set the millivoltage switch to "-" and turn the slidewire scale setter until the high-end division of the scale (11) is under the slidewire scale index.

(5) Apply -11mV to the potentiometer.

(6) Lock down the DETECTOR key.

(7) Adjust the position of the slidewire contact on the slidewire until the detector balances. To do this, loosen the screws that secure the contact assembly to the slidewire casting, adjust the contact position as required, and then tighten the screws to secure the contact assembly in place. Make sure that the contact bears against the slidewire with a force of two to three ounces. Refer to Section 16C for instructions for measuring and adjusting the contact force.

(8) Set the millivoltage switch to 00 and turn the slidewire scale setter until the low-end division of the scale (0) is under the slidewire scale index.

(9) Disconnect the source of calibrated voltage from the EMF binding posts. Then short these posts with a piece of copper wire.

(10) Loosen the locknut on the trimmer rheostat, Fig. 4, and adjust the rheostat until the detector balances.

(11) Repeat Steps 4 to 10 inclusive. Then tighten the locknut on the trimmer rheostat to secure its adjustment.

(12) Other points on the slidewire scale and other positions of the millivoltage switch may now be checked in a similar manner. DO NOT disturb the position of the slidewire contact or the adjustment of the trimmer rheostat when making these checks. The limit of error of these checks should not exceed ±[0.05% of the potentiometer reading + 15μV].

(13) Finally, place the function switch in the OFF position, unlock the DETECTOR key, disconnect the source of the calibrated voltage from the EMF binding posts, and remount the control panel in the potentiometer case.

21. AUXILIARY EQUIPMENT

Refer to L&N Catalog HO-0001 for thermocouple assemblies, parts, and accessories.

22. REPLACEMENT PARTS

The replacement parts for 8690-2 Millivolt Potentiometer are listed in Table II.

TABLE II—REPLACEMENT PARTS

DESCRIPTION	PART NUMBER
Detector Meter	021177
Detector Zero Control	013496
Detector Printed Circuit Card	444514
Detector-Circuit Battery; 4.05-volt; Eveready No. E133N or equivalent	056056
Detector Key	031014 (PI-123-S-1)
Binding Post Head	002199
Function Switch	032521
Scale Window	369320
Battery Rheostat	013202
Standard Cell	130031
Slidewire Contact Assembly	029610
Trimmer Rheostat (S2)	013203
Standard Cell Voltage Divider (S4)	013203
Potentiometer-Circuit Battery; 1.5-volt; Burgess 4FH or equivalent	056004 (Std. 2233-1)
Latch	071140
Handle	046008
Bumper	041002 (41-2-11-2)
Panel Mounting Screw Assembly	
Screw	004223 (4-4-1-24)
Bushing	006118 (6-2-1-2)
Upper Spring	028210 (28-1-3-10)
Lower Spring	028209 (28-1-3-9)
Clamp	072118 (72-4-1-1)
Retaining Ring	027016 (27-3-3-12)

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